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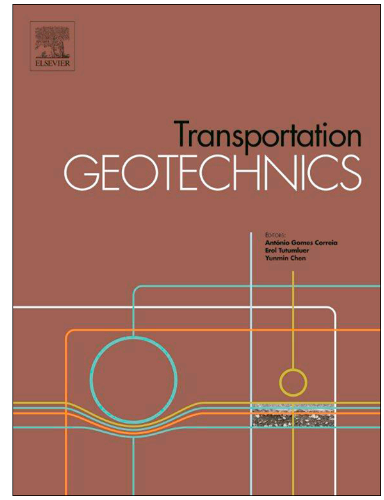

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THE EFFECT OF WETTING AND DRYING ON THE PERFORMANCE OF STABILIZED SUBGRADE SOILS

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ABSTRACT

Stabilization methods are often utilized to improve the performance of road pavement subgrades which are weak or susceptible to small changes in moisture content. However, although a variety of performance models for natural materials have been developed and incorporated within road pavement design methodologies little research attention has been given to the characterization of similar performance models for stabilized subgrade soils. To address this, the research reported herein describes and discusses the results of a laboratory testing programme, incorporating cycles of wetting and drying, for a number of stabilized subgrade soils to determine the resilient behaviour and permanent deformation characteristics of the soils. The results from the experiments were used to characterize six models of subgrade soil permanent deformation performance identified from the literature and from these to develop a new improved model of performance which incorporates resilient behaviour. A comparison of the existing models of permanent deformation showed that those which consider stress state in addition to the number of load repetitions are better able to predict permanent deformation than those which consider the number of load cycles only. Samples subject to wetting and drying exhibited significantly greater permanent deformation and had lower values of resilient modulus than those which were not subject to wetting and drying. The usefulness of the results for analytical road pavement design are demonstrated by using a back-analysis procedure to determine appropriate resilient modulus values to characterise an analytical model of a road pavement together with the performance models to predict road pavement subgrade performance under cumulative applications of traffic load. Accordingly, the results show the importance of adequately replicating material behaviour in field conditions. In particular, the design process must utilize resilient modules values and deformation models which are determined in conditions which take into account in-situ stresses and cycles of wetting and drying.

1. INTRODCUTION

Analytical pavement design consists of two main processes. One is associated with development and characterization of numerical models to enable actual stresses and strains at any point within a road pavement to be determined. This requires the resilient modulus, Poisson's ratio and material density to be characterized and utilized within the model.

It is important to determine the resilient modulus value(s) to be used with a numerical model under the variety of conditions to which the road pavement is likely to be subjected. The resilient modulus may be affected by many factors such as stress level, soil type, amount of stabilization and moisture fluctuations [1, 2, 3 and 4]. The moisture within a road pavement fluctuates according to the immediate environment and its influence on resilient modulus is most apparent when spring thawing is followed by a period drying during the summer months. Such a repetition of prolonged wetting and drying can adversely affect the performance of the road pavement structure.

The second process within analytical road pavement design is associated with empirical studies to ascertain the number of load cycles to which the materials within the pavement can undergo before failure, i.e. the development of so called performance models. The design is formulated by setting limits to the stresses, strains and deformations at critical locations within the theoretical model. Usually such limits are applied to prevent fatigue cracking at the bottom of the bituminous layer, limit permanent deformation (rutting) within the subgrade [5] and or limit surface deflection [6- 8].

For fatigue cracking the limit is set to control the tensile strain beneath the bituminous layer whereas for rutting it is usual to set a limit on the compressive strain at the top of the subgrade or a rut depth limit at the surface of the road pavement. However, each layer in a pavement structure contributes to the total surface rutting development, i.e. the rut is the sum of the permanent deformation of all layers of the pavement structure. As far as stabilized materials are concerned, pavement design standards such as the AASHTO pavement design guide, MEPDG [9] specify that pavements with one or more stabilized layers should be designed for fatigue cracking alone, but not for rutting (since it often assumed that permanent deformation is zero in these standards). However, research by Wu et al. [10, 11] and others show that permanent deformation can occur in stabilized soils.

Several researchers have related the accumulation of permanent deformation in the subgrade to the number of load repetitions [12, 13], others have linked permanent deformation to the applied stresses [14, 15] and others have produced modified versions of these models through introducing different soil properties such as moisture content and measures of strength [16-18]. However, the literature associated with permanent deformation development in stabilized base and/or subgrade layers is limited [see for example 10, 19-21].

To address the apparent lack of stabilized subgrade soil performance models and their use within analytical pavement design, research was carried out to i) determine how representative values of resilient modulus for stabilized subgrade soils can be obtained by laboratory experimentation, and ii) identify suitable models of stabilized subgrade material performance which accurately replicate in-situ permanent deformation behavior under cumulative load. The developed model is demonstrated via an analytical pavement design procedure.

2. LABORATORY TESTING PROGRAM

Three different types of subgrade soils were used. The soils are representative of subgrades which may be found in Kurdistan. The index properties and moisture-density relationships of the soils were determined using standard laboratory tests and are shown in tables 1 and 2. Three soils were stabilized with cement and a combination of cement and lime as follows: 2%CC, 4%CC, 2%CC+1.5%LC and 4%CC+1.5%LC (CC and LC denote Cement and Lime Contents respectively).

A number of laboratory tests were performed on the samples as follows:

1) Permanent deformation tests: There is no widely accepted standard specification procedure for a permanent deformation test for subgrade soils. For this research, therefore it was decided to use a process based on both AASHTO T307 [22] and BS EN 13286-7 [23]. The stress levels specified to determine the resilient modulus of subgrade soils in AASHTO T307 together with the specified apparatus were used in combination with the procedure mentioned in BS EN 13286-7. The number of loading cycles was chosen to be 50,000 cycles.

2) Resilient modulus tests: For the resilient modulus test the procedure of AASHTO T307 was followed [24]. The test requires the preconditioning of a soil sample with 500-1000 cycles with a confining pressure and deviatoric stress of 41.4 kPa and 27.6 kPa, respectively. The test requires different combinations of confining pressure and deviatoric stresses to be applied for 100 cycles for 15 sequences. The results from the last five cycles were averaged to obtain the resilient modulus of a specified stress combination.

3) Wetting and drying tests: Wetting and drying consists of cycles of wetting the soil sample by submerging it in water at room temperature for a period of time followed by drying in an oven. The ASTM D 559 [25] procedure specifies that a cycle should consist of submerging the sample for 5 hrs and thereafter drying the sample in an oven at a temperature of 71˚±3˚ for a further 42 hours. Twelve such wetting and drying cycles are specified during which soil losses, volume and moisture changes are recorded. Chittoori et al. [19] adapted ASTM D 559 by using 21 cycles of wetting and drying to compare the strength of the stabilized soils in terms of the Unconfined Compressive Strength (UCS) after 3, 7, 14 and 21 cycles. For this research, it was therefore decided to use 25 wetting and drying cycles after which the resilient modulus value of the three soils were determined according to AASHTO T307.

3. THE MODEL DEVELOPMENT

Six models of material performance were identified from the literature for the purposes of comparing their suitability to predict the development of plastic strain of stabilized soils. The models identified are as follows:

1) Veverka model [15]

$$\varepsilon_{1,p} = a * \varepsilon_r * N^b \tag{1}$$

In which $\varepsilon_{1,p}$ is accumulated permanent strain, ε_r is the resilient strain, N is the number of load repetitions and a and b are regression parameters. This model relates the accumulated permanent deformation to the number of load repetitions and the resilient strain.

2) Khedr model [16]

$$\frac{\varepsilon_{1,p}}{N} = A * N^{-m} \tag{2}$$

In which A and m are regression parameters

3) Sweere model [16]

$$\mathcal{E}_{1,p} = a * N^b \tag{3}$$

4) Ullidtz model [25]

$$\mathcal{E}_{1,p} = AN^{\alpha}[\frac{\sigma_z}{P}]^{\beta} \tag{4}$$

Where $\mathcal{E}_{1,p}$: is the vertical plastic strain in micro strains, σ_z is the vertical stress at depth z, P is a reference stress (atmosphere pressure) and A, α and β are constants.

5) Puppala model [19]

$$\mathcal{E}_{1,p} = \alpha_1 N^{\alpha_2} \left(\frac{\sigma_{oct}}{\sigma_{atm}}\right)^{\alpha_3} \left(\frac{\tau_{oct}}{\sigma_{atm}}\right)^{\alpha_4} \tag{5}$$

Where:$\sigma_{oct} = (\sigma_1 + 2\sigma_3)/3$, $\tau_{oct}(\sqrt{2}/3)(\sigma_1 - \sigma_3)$, σ_{atm} is the reference stress and α_1, α_2, α_3 and α_4 are constants.

6) Li and Selig model [17]

$$\varepsilon_{1,p} = a * (\frac{\sigma_d}{\sigma_s})^m * N^b \tag{6}$$

Where σ_d is the deviatoric stress; σ_s is the soil static stress and *a*, *m* and *b* are material specific parameters. Li and Selig's model accounts for the effect of moisture change and material performance through the soil static stress. It was also decided to investigate the use of a seventh hybrid model (the model developed in this research) which is relatively easy to calibrate and takes into account the effect of moisture via a resilient mechanical property, namely the resilient modulus. The postulated model is as follows:

$$\varepsilon_{1,p} = I * \left(\frac{\sigma_d}{M_r}\right) * N^J \tag{7}$$

Where: M_r is resilient modulus and I and J are regression parameters

4. RESULTS

Table 3 shows a comparison of the measured permanent strain of the three soil samples considered at a variety of moisture contents with the values of permanent strain predicted using the 6 models described above. In each case the model parameters were determined from the permanent deformation test results for stabilized soils with 4%CC+1.5%LC and unstabilized soils at three different moisture contents of 80% of OMC, OMC and 120% of OMC. As can be seen the coefficient of significance (R^2) values in relation to the goodness of fit of the 6 equations with the actual permanent deformation lie between 0.875 and 0.989 for native soils at optimum moisture content, irrespective of whether the model includes a measure of stress. The R^2 values however for stabilized soils are low for models containing only the number of load repetitions (models 2 and 3) and vary between 0.475 and 0.773. Models containing the stress state have higher coefficient of significance, ranging between 0.786 and 0.935. This highlights the significance of including the stress level within the permanent deformation models.

Tables 4- 6 show the resilient modulus values for soils A-4, A-6 and A-7-5 respectively, determined from the laboratory procedure. As can be seen stabilization increased the resilient modulus values for all soil types and different stabilizer contents, however by differing amounts ratios. The results also show the decrease in resilient modulus values after cycles of wetting and drying. It should be noted that the missing values apparent in Tables 5 and 6 of wetting and drying for soils A-6 and A-7-5 is because the soils collapsed after the first few cycles of wetting and drying.

5. PAVEMENT DESIGN

A hypothetical road pavement section was used to examine the performance of the three soil types, subject to wetting and drying (see table 7), under a standard axle load of 80 KN. The KENLAYER program [8] was used to perform the analytical component of the pavement design procedure by modelling the hypothetical road pavement. The analysis performed consisted of determining, using KENLAYER, the maximum deviator stress σ_d at the mid-depth of the stabilized subgrade layer for the different materials considered under a number of wetting and drying environments. The deviator stress was utilized within a model of material performance (equation 7) to determine the permanent strain which would accrue after 10,000 load cycles. The coefficients I and J in equation 7 were determined using the permanent deformation test with single-stage at deviatoric stress and confining pressures of 62.0 kPa and 27.6 kPa respectively. The coefficients determined for each soil type are shown in table 8.

In order to take into account, the stress dependency of the resilient modulus of the stabilized layer an iterative back analysis procedure was developed. This consisted of obtaining a seed resilient modulus value for use in KENLAYER, which was taken from the laboratory tests for each deviatoric stress at the three confining pressures. Thereafter the deviatoric stresses at mid-depth in the stabilized layer were computed via KENLAYER and used to determine a new resilient modulus value. This process was repeated until the computed deviatoric stresses and those used to determine the laboratory resilient modulus values converged. The final resilient modulus values so computed were also used within the model for permanent deformation determination, see Figures 1-3; that show the relation between the deviatoric stress and the resilient modulus obtained from test results and used for the aforementioned procedure.

Table 9 shows the resilient modulus values and the deviatoric stresses produced from KENLAYER and the calculated plastic strains for each soil type considered. As can be seen the stabilization improved the permanent deformation resistance of these three soils, for example the permanent deformation of soils A-4, A-6 and A-7-5 decreased from 3280 micro-strains to 726 micro-strains, from 2499 micro-strains to 571 micro-strains and from 1673 micro-strain to 1177 micro-strains with 2%CC stabilization, respectively. However, the exposure of the stabilized soils to cycles of wetting and drying reduces their resistance to permanent deformation (Table 9). For example, from 726 micro-strains to 1469 micro-strains for soil A-4 stabilized with 2% cement content.

From the analysis, it is apparent that stabilizing soils A-4 and A-6 with 4% cement content provides a more resilient material than those stabilized using the other scenarios. These two soils contain a higher proportion of sand and silt, which perform better when stabilized with cement than lime, confirming observations from the literature [26]. On the other hand, soil A-7-5, which contains a higher proportion of clay, reacts better to a combination of lime mixed with cement. However, for practical purposes a single stabilizer type and ratio is preferred as different soil types may be present in one project. From this point of view, therefore, stabilization with 4% cement may provide the most satisfactory results from a resilience and practical point of view.

6. CONCLUSIONS

This paper has described a series of laboratory tests which were carried out to quantify the changes to the resilient modulus and permanent deformation of stabilized subgrade soils subject to cycles of wetting and drying. A series of tests were conducted on three types of subgrade soils that were stabilized to varying degrees with combination of lime and cement. Seven different models were used to predict the performance of the soils in terms of plastic strain.

To demonstrate the influence of the soil types on road pavement performance, the laboratory formulated measures of performance were utilized within a numerical model.

The following main conclusions can be drawn from this work:

1. Fine-grained soils with a higher portions of clay content need a higher stabilizer agent ratio than soils with a higher portion of sand and silt, as the later behaves similarly to coarse granular material rather than a fine-grained soil.

2. Wetting and drying was shown to have a significant effect on both the resilient modulus and on the development of permanent strain. It is therefore important within an analytical pavement design procedure to ensure that material parameters and models of material performance have been characterized under conditions which adequately replicate those found in the field, including under conditions of wetting and trying.

3. An iterative back-analysis procedure was developed to determine appropriate resilient modulus values which take into account the nonlinear behavior of the stabilized and unstabilized subgrade soils, together with in-situ environmental conditions.

4- Although stabilization can improve the resistance of the soil to permanent deformation, subgrade permanent deformation of such soils increases with both the applied stress level and after cycles of wetting and drying.

5- Equations of permanent deformation that consider stress state in addition to the number of load repetitions are better able to predict permanent deformation.

6- The equipment and procedures of AASHTO T307 and BS EN 13286-7 were found to be suitable for permanent deformation tests of unstabilized and stabilized subgrade soils albeit with some refinement.

7- An equation developed to predict permanent deformation can be used jointly with a numerical model (such as KENLAYER) to calculate the permanent deformation of unstabilized and stabilized subgrade layers.

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Table 1 Index properties of the soils

Index limits	Soil type A-4	A-6	A-7-5	Standard used
Liquid limit LL (%)	21	35	51	BS1377-2:1990 Sections 4 and 5
Plastic limit PL (%)	14	21	31	
Plasticity Index PI (%)	6	14	20	

Table 2 Maximum dry density and optimum moisture contents for stabilized and unstabilized soils

Soil type	MDD (gm/cm^3)	OMC (%)	Standard used
Untreated			BS1377-4:1990 section 3
A-4	1.913	10.3	
A-6	1.889	11.0	
A-7-5	1.485	21.5	
Treated 2%CC			BS1924-2:1990 Section 2
A-4	1.853	12.3	
A-6	1.862	13.0	
A-7-5	1.48	23.0	
Treated 4%CC			
A-4	1.847	13.2	
A-6	1.845	13.5	
A-7-5	1.465	23.5	
Treated 2%CC+1.5%LC			
A-4	1.845	13.0	
A-6	1.847	13.4	
A-7-5	1.472	24.0	
Treated 4%CC+1.5%LC			
A-4	1.838	14.0	
A-6	1.842	14.0	
A-7-5	1.463	24.5	

Table 3 Parameters of performance models used

Soil type and moisture content	Veverka			Sweere			Ullidtz			
	a	b	R^2	a	b	R^2	A	α	β	R^2
A-480%OMC U*	1.955	0.086	0.908	907.069	0.059	0.911	1433.858	0.05	0.757	0.983
A-4100%OMC U	1.825	0.165	0.908	1407.350	0.104	0.954	2974.936	0.098	1.418	0.993
A-4120%OMC U	1.240	0.440	0.969	1549.491	0.398	0.974	2098.81	0.393	0.561	0.974
A-680%OMC U	1.055	0.076	0.945	670.450	0.060	0.912	1021.733	0.052	0.694	0.973
A-6100%OMC U	1.843	0.107	0.938	1805.006	0.084	0.897	7597.117	0.067	2.572	0.981
A-6120%OMC U	2.031	0.341	0.965	3355.053	0.317	0.972	5972.695	0.308	1.052	0.979
A-7-580%OMC U	1.233	0.035	0.861	920.792	0.032	0.712	1407.552	0.023	0.681	0.939
A-7-5100%OMC U	1.068	0.055	0.907	941.833	0.053	0.875	1447.777	0.044	0.706	0.961
A-7-5120%OMC U	1.582	0.067	0.901	2145.541	0.060	0.799	5595.023	0.046	1.68	0.953
A-4100%OMC TΔ	1.075	0.042	0.475	423.211	0.028	0.643	568.995	0.021	0.47	0.789
A-6100%OMC T	1.228	0.047	0.773	425.139	0.033	0.752	620.169	0.024	0.604	0.935
A-7-5100%OMC T	2.205	0.038	0.623	988.538	0.023	0.571	1414.698	0.014	0.567	0.858

* U denoted for Unstabilized

Δ T denoted for stabilized

Continued

Soil type and moisture content	Puppala					Khedr			Li and Selig			
	α_1	α_2	α_3	α_4	R^2	b	A1	R^2	a	m	b	R^2
A-480%OMC U	0.401	0.05	1.93	0.096	0.985	0.941	907	0.911	0.326	0.757	0.05	0.983
A-4100%OMC U	0.023	0.087	1.989	1.037	0.989	0.896	1405	0.954	0.986	1.418	0.098	0.988
A-4120%OMC U	32.248	0.392	0.725	0.329	0.975	0.602	1549	0.974	0.289	0.559	0.394	0.975
A-680%OMC U	0.135	0.05	2.35	-0.138	0.976	0.940	670	0.912	0.196	0.694	0.052	0.973
A-6100%OMC U	0.001	0.064	2.674	1.393	0.985	0.916	1805	0.897	6.187	2.572	0.067	0.981
A-6120%OMC U	1405.191	0.313	-0.976	1.383	0.979	0.683	3355	0.972	1.087	1.052	0.308	0.979
A-7-580%OMC U	8.91	0.021	0.907	0.366	0.941	0.968	920	0.712	0.301	0.681	0.024	0.939
A-7-5100%OMC U	0.171	0.044	2.351	-0.112	0.966	0.947	941	0.875	0.276	0.706	0.044	0.961
A-7-5120%OMC U	0.508	0.043	1.094	1.266	0.953	0.940	2145	0.799	1.724	1.68	0.046	0.953
A-4100%OMC T	0.179	0.018	2.33	-0.343	0.797	0.972	423	0.643				
A-6100%OMC T	6.744	0.023	0.808	0.329	0.935	0.967	425	0.752				
A-7-5100%OMC T	0.067	0.01	2.887	-0.438	0.872	0.977	988	0.571				

Table 4 Resilient modulus values for soil A-4 at unstabilized, stabilized and stabilized after wetting and drying cycles (WD denotes for wetting and drying)

Confining pressure (kPa)	Deviatoric Stress (kPa)	Untreated Mr (Mpa)	2%CCT Mr (Mpa)	2%CCWD Mr (Mpa)	4%CCT Mr (Mpa)	4%CCWD Mr (Mpa)	2%CC+1. 5%LCT Mr (Mpa)	2%CC+1. 5%LCWD Mr (Mpa)	4%CC+1. 5%LCT Mr (Mpa)	4%CC+1. 5%LCWD Mr (Mpa)
41.4	12.4	117	131	72	176	132	111	76	135	121
41.4	24.8	140	161	82	202	146	135	93	172	141
41.4	37.3	155	187	92	220	162	158	106	200	155
41.4	49.7	163	210	103	239	184	182	120	228	170
41.4	62.0	170	226	113	258	205	203	134	256	185
27.6	12.4	113	135	71	167	128	105	74	131	117
27.6	24.8	136	162	81	194	143	129	89	165	137
27.6	37.3	150	185	90	214	159	152	103	195	152
27.6	49.7	160	206	102	236	180	176	117	224	166
27.6	62.0	168	223	112	256	201	198	131	250	183
12.4	12.4	99	127	68	162	123	100	70	121	113
12.4	24.8	132	156	78	187	139	124	86	159	132
12.4	37.3	146	182	89	209	156	147	100	190	147
12.4	49.7	157	203	99	231	177	171	114	218	163
12.4	62.0	165	222	110	252	197	193	128	245	178

Table 5 Resilient modulus values for soil A-6 at unstabilized, stabilized and stabilized after wetting and drying cycles (WD denotes for wetting and drying)

Confining pressure (kPa)	Deviatoric Stress (kPa)	Untreated Mr (Mpa)	2%CC Mr (Mpa)	4%CC Mr (Mpa)	4%CCWD Mr (Mpa)	2%CC+ 1.5%LC Mr (Mpa)	2%CC+ 1.5%LCWD Mr (Mpa)	4%CC+ 1.5%LC Mr (Mpa)	4%CC+ 1.5%LCWD Mr (Mpa)
41.4	12.4	96	139	122	93	113	78	121	99
41.4	24.8	107	160	151	107	133	89	156	116
41.4	37.3	109	174	177	120	149	97	177	133
41.4	49.7	106	187	199	136	162	107	195	148
41.4	62.0	102	200	221	152	175	117	213	167
27.6	12.4	93	136	117	91	110	77	115	94
27.6	24.8	103	156	146	103	129	85	148	111
27.6	37.3	105	171	173	117	145	94	170	127
27.6	49.7	102	185	195	132	159	104	189	145
27.6	62.0	101	198	217	149	172	116	209	164
12.4	12.4	85	133	110	87	106	74	109	91
12.4	24.8	100	153	140	100	126	83	142	108
12.4	37.3	102	168	166	114	141	93	166	125
12.4	49.7	101	182	190	129	156	103	186	142
12.4	62.0	100	196	212	145	170	113	205	161

Table 6 Resilient modulus values for soil A-7-5 at unstabilized, stabilized and stabilized after wetting and drying cycles (WD denotes for wetting and drying)

Confining pressure (kPa)	Deviatoric Stress(kPa)	Untreated Mr (Mpa)	2%CCT Mr(Mpa)	4%CCT Mr(Mpa)	2%CC+ 1.5%LCT Mr (Mpa)	2%CC+ 1.5%LCT Mr (Mpa)	2%CC+ 1.5%LCWD Mr (Mpa)
41.4	12.4	74	76	101	123	125	84
41.4	24.8	75	90	117	137	140	90
41.4	37.3	72	101	127	146	152	99
41.4	49.7	64	111	136	152	163	108
41.4	62.0	57	121	143	158	174	117
27.6	12.4	72	75	96	119	118	78
27.6	24.8	73	87	112	133	133	83
27.6	37.3	69	98	124	142	147	90
27.6	49.7	62	108	134	150	159	100
27.6	62.0	57	119	141	157	172	111
12.4	12.4	70	72	92	113	116	77
12.4	24.8	72	85	108	131	131	83
12.4	37.3	68	96	121	140	144	91
12.4	49.7	62	107	130	149	157	102
12.4	62.0	57	117	138	156	169	112

Table 7 Pavement section dimensions

Layer	Thickness (mm)	Resilient modulus (Mpa)	Poisson's Ratio
Surface course (Asphalt concrete)	100	3500	0.3
Base course (Unbound granular material)	200	350	0.35
Subgrade (Compacted fine-grained soil)	200	variable	0.45
Subgrade (Natural)	-	variable	0.45

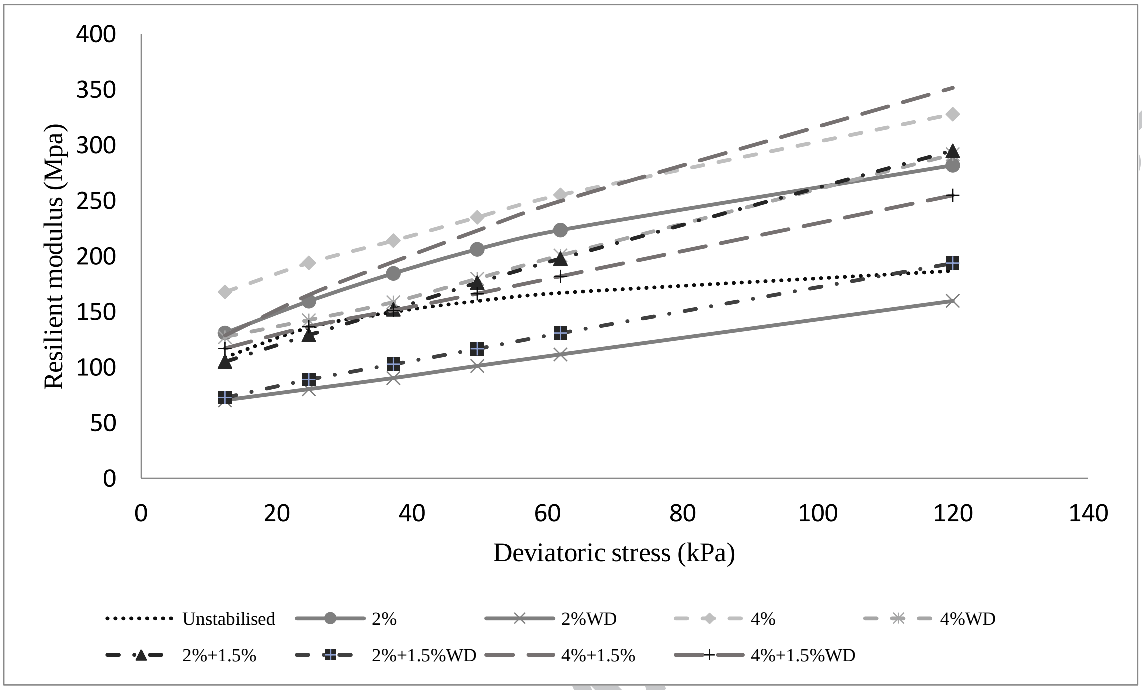

Figure 1 Deviatoric stress to resilient modulus relation curves for soil A-4

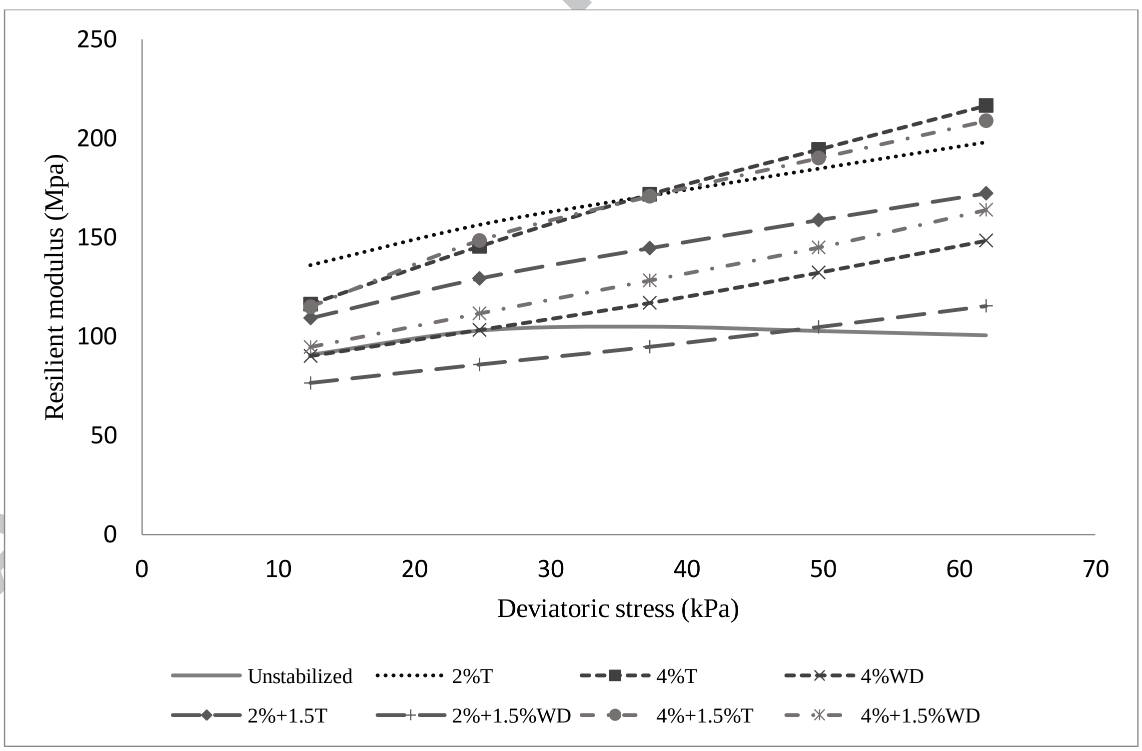

Figure 2 Deviatoric stress to resilient modulus relation curves for soil A-6

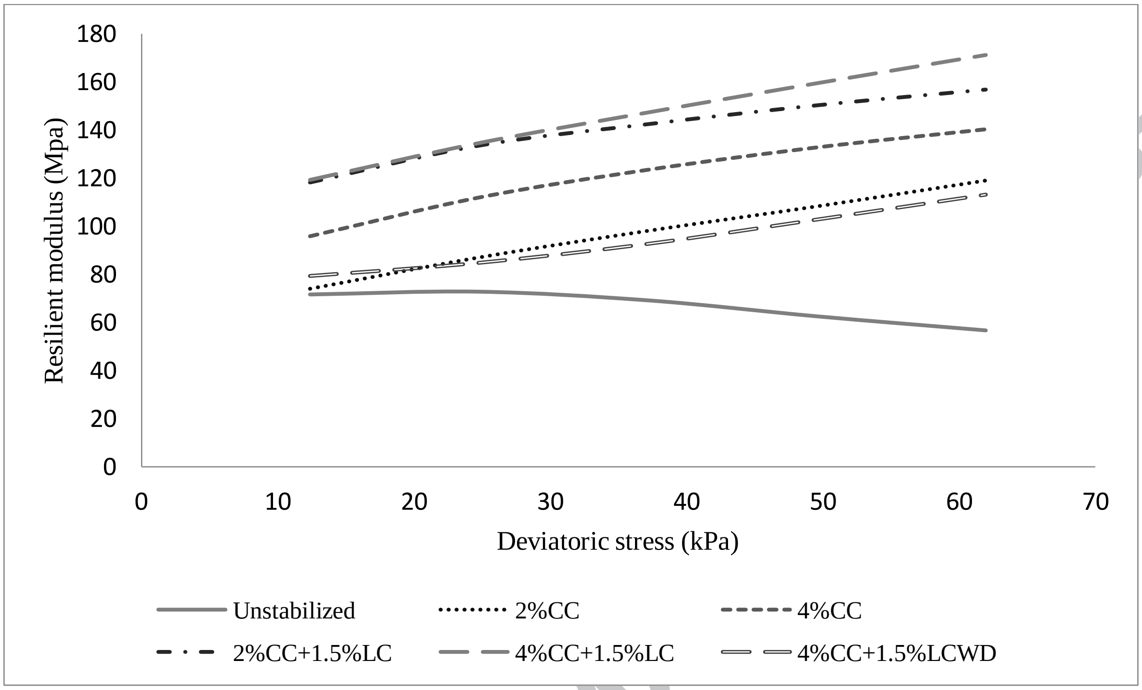

Figure 3 Deviatoric stress to resilient modulus relation curves for soil A-7-5

Table 8 Parameters of the performance equation for the three soils

Soil type	*I*	*J*	R^2
A-4 (Unstabilized)	669.81	0.286	0.982
A-6 (Unstabilized)	273.645	0.322	0.996
A-7-5 (Unstabilized)	363.736	0.219	0.969
A-4 (Stabilized)	692.084	0.15	0.474
A-6 (Stabilized)	357.319	0.192	0.938
A-7-5 (Stabilized)	597.297	0.17	0.799

Table 9 Permanent deformation calculation for different soil types and stabilizer contents

Soil type	Stabilizer content	Mr(Mpa)	DS* (kPa)	I	J	$\varepsilon_{1,p}$ (μ Strain)
A- 4	Unstabilized	165	58	669.81	0.286	3280
	2%CCT	258	68	692.084	0.15	726
	2%CCWD	105	56	692.084	0.15	1469
	4%CCT	253	60	692.084	0.15	653
	4%CCWD	192	59	692.084	0.15	847
	2%CC+1.5%LCT	195	60	692.084	0.15	848
	2%CC+1.5%LCWD	125	57	692.084	0.15	1256
	4%CC+1.5%LCT	245	60	692.084	0.15	675
	4%CC+1.5%LCWD	178	59	692.084	0.15	913
A-6	Unstabilized	102	48	273.645	0.322	2499
	2%CCT	187	51	357.319	0.192	571
	2%CCWD	-	-	357.319	0.192	-
	4%CCT	198	51	357.319	0.192	539
	4%CCWD	132	50	357.319	0.192	793
	2%CC+1.5%LCT	160	50	357.319	0.192	654
	2%CC+1.5%LCWD	105	49	357.319	0.192	977
	4%CC+1.5%LCT	195	51	357.319	0.192	548
	4%CC+1.5%LCWD	147	50	357.319	0.192	712
A-7-5	Unstabilized	67	41	363.736	0.219	1673
	2%CCT	102	42	597.297	0.17	1177
	2%CCWD	-	-	597.297	0.17	-
	4%CCT	128	43	597.297	0.17	960
	4%CCWD	-		597.297	0.17	-
	2%CC+1.5%LCT	146	43	597.297	0.17	842

	2%CC+1.5%LCWD	-	-	597.297	0.17	-
	4%CC+1.5%LCT	153	43	597.297	0.17	803
	4%CC+1.5%LCWD	96	42	597.297	0.17	1251

*Deviatoric Stress